MASSACHUSETTS

INSTITUTE OF TECHNOLOGY,

BOSTON.

COURSES OF INSTRUCTION

RELATING TO

HYGIENE, SANITARY SCIENCE, AND BIOLOGY.

PREPARED FOR THE MEETING OF

MASSACHUSETTS MEDICAL SOCIETY,

IN BOSTON, JUNE 7 AND 8, 1892.

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Prepared for the meeting of Massachusetts Medical Society, in Boston, June 7 and 8, 1892.

The instruction given at the Massachusetts Institute of Technology comprises, in addition to six branches of Engineering, namely, Civil, Mechanical, Mining, Electrical, Chemical, and Sanitary Engineering, courses in Architecture, Chemistry, Physics, Biology, Geology, and Political Science.

All of these subjects are more or less nearly related to the public health, and it has been the aim of the Faculty of the Institute to give due weight to all questions of hygiene, which properly form part of these courses of instruction. The intimate connection between many of these subjects and the sanitary welfare of the community is at once apparent when we consider that the building of water works and sewers devolves on the Engineer, that the sanitary construction of houses, their drainage and ventilation, belongs to the Architect, and that the tests for purity of our food, air, and water rest on the authority of the Chemist and Biologist.

In all the departments of instruction, prominence is given to laboratory work. Not only in Chemistry, Physics, and Biology, where the laboratory is an essential feature of all modern instruction, but also in the Engineering departments, actual experience with machines and tests of their efficiency

are required of the student. Original investigations and designs form a part of the work of the senior year * and the ability to do original work is a necessary qualification for graduation.

In all the technical courses of the Institute there is also considerable time devoted to studies of a general character, — Language, Literature, History, and Political Science, that the graduates may not lack for these essential qualifications of an educated man.

In the following pages is given, in some detail, a description of the courses of instruction which relate especially to hygiene and sanitary matters.† The first place is appropriately given to Biology, which forms one of the main departments of the Institute.

DEPARTMENT OF BIOLOGY.

This department of the Institute is especially connected with sanitary and medical science, for Biology, the science of life, includes not only physiology, the science of function, and morphology, the science of form, but also ætiology, the science of causation, and pathology, the science of disease. As sub-divisions of zoölogy and botany it includes, also, anatomy, histology, anthropology, sociology, bacteriology, and sanitary science.

General Biology is used as the introductory subject, and it is taken by second-year students. In this course the elementary anatomy and physiology of organisms, in general,

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* For instance, during the present term at the Institute, students of the senior class have been investigating the efficiency of many kinds of fans used for the ventilation of buildings.

† Those who desire further information of the Institute as a whole are referred to the annual catalogue.

are studied from representative examples of plants and animals. Such subjects as organs, tissues, cells, protoplasm, differentiation, vital energy, work, adaptation, environment, primitive metabolism, and the fundamental physiological properties of all living things, are dwelt upon and made real by laboratory exercises upon illustrative forms. The use of the microscope is emphasized; its special construction and employment, for measuring, drawing, and other technical purposes, are made the subject of fifteen separate exercises in the second half of the same year. In this year, also, General Zoölogy and General Botany are taught as essential preliminaries to higher and more special work.

In the third year the subjects become still more special and semi-professional. Comparative Anatomy is taught in a long course of dissections of, first, a few invertebrates (hydra, starfish, clam, lobster, insect), stress being laid on the parasitic forms, and, secondly, of typical vertebrates, especially mammals. The importance of this course, as the only sound foundation of anatomy, and the key to many aberrant phenomena in man, as well as its demonstration of the fundamental facts of evolution, cannot be overestimated. One of the most promising fields, now open to the medical sciences, lies in Comparative Biology, which includes Comparative Anatomy, Comparative Embryology, Comparative Physiology, and Comparative Pathology. The recent discoveries of Metschnikoff have awakened the liveliest interest in the comparative pathology of inflammation, as well as in practical hygiene. No one can really appreciate these revelations who is not acquainted with Comparative Anatomy, Comparative Physiology, and the *rôle* of phagocytes in the removal from animal bodies of dead matter as well as parasitic germs. Cryptogamic Botany is also a third year subject; and the splendid labors of Pasteur, which have given to the world the first reasonable explanation of the æti-

ology of zymotic disease, compel the thorough student of medical science to know the botanical relations of microphytes in all their complexity. A special course in microorganisms gives opportunity for comparing the microzoa with the microphytes, and for comprehending such subjects as parasitism and sex.

It is in the fourth year, however, that the relations of Biology to Medicine become most apparent. Comparative Physiology is here the principal subject; and in this conferences are held five times a week throughout the year. These are associated with dissections and laboratory work, physical and chemical, upon living or fresh animal tissues.

Bacteriology, with special reference to sanitary work, is a prominent feature of the year. The students learn how to make their own culture media, how to examine milk, water, air, ice, soil, etc., for pathogenic germs, and how to test the efficiency of filters, sterilizers, and germicides. Here, as in all the other courses mentioned, constant laboratory work is required. In higher Biology lectures are given upon Darwinism, heredity, natural selection, degeneration, variation, phagocytosis, immunity, etc. In this year also an opportunity is offered for work in organic chemistry and in the organic laboratory.

Especially noteworthy are the courses upon Sanitary Science. In one of these the biological phenomena of communities, such as population, birth rate, death rate, morbidity, lethality, are studied. Ancient and modern theories of disease are reviewed and compared; the causes of death; longevity and other social phenomena; the origin and natural history of epidemics; the pollution and the purification of water; the disposal of sewage, garbage, and the dead; the phenomena of dust and its dangers; the pollution of milk, food stuffs, and ice; the self-purification of rivers; and the like, are dealt with from the point of view of Sanitary Biology, Sanitary Science, and the Public Health.

DEPARTMENT OF CHEMISTRY.

The course in Chemistry comprises instruction in general, theoretical, analytical, organic, industrial, and sanitary chemistry, by text-book, lectures, and laboratory practice. The chemical laboratories afford accommodations for five hundred and fifty students in fifteen rooms. The laboratory of general chemistry has places for three hundred and twenty students, and during the past year three hundred and twenty-five students have been working here. The analytical laboratory can accommodate one hundred and fifty students and possesses every convenience for accurate and rapid analytical work. The organic laboratories have places for thirty students, the sanitary laboratories for sixteen students, and the industrial laboratories for thirty students. During the present year two more large rooms will be converted into chemical laboratories. The equipment of the laboratories in permanent fittings and in apparatus is unsurpassed in this country. The chemical library has more than five thousand volumes and two thousand pamphlets, and is kept in the reading room of the department. It contains complete sets of the most important chemical periodicals.

The description of the course of instruction in the Chemical Department will be limited, in this publication, to the special department of Sanitary Chemistry which has immediate bearing on matters relating to the public health. The principal work here is the examination of air, water, and food, — the three essentials of healthy living. The student is not permitted to take this work in Sanitary Chemistry unless he has successfully pursued, for one year, a course in general chemistry with laboratory practice, followed by a year of qualitative and quantitative analysis. Problems of the importance of those with which the sanitary chemist has to deal, should not be undertaken except by one well equipped both in chem-

ical knowledge and in chemical practice. The course in air analysis consists in a series of examinations of samples of air taken at a number of points in a room, and a study of the conditions affecting the results.*

The regular work in the examination of foods consists in the analysis of butter, milk, oleomargarine, flour, etc., and facilities are given for special investigations of all kinds of food. As a simple illustration of the method of instruction, tending to make one cautious in drawing conclusions from his work, may be cited an exercise given to the students to determine the composition of a sample of milk in its upper, lower, and middle third, after transportation by cars or wagon, and after standing varying lengths of time. In the same line of work, the student is led to investigate the relations of the lactic to the putrefactive fermentations in milk.

In sanitary water analysis, the Institute of Technology occupies an unique position in the schools of the country. The great work of the Massachusetts State Board of Health,

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* Compare with the course in heating and ventilation in the Department of Physics.

As an illustration of the character of this work may be given the following results actually obtained by the students on two occasions in analyzing air for carbonic acid every ten minutes during the occupancy of a room. The capacity of the room (with sloping floor) was 25,000 cubic feet, with an average height of thirteen feet. The samples were taken on one side of the room away from the windows at a point eight feet below the ceiling. Two hundred students entered the room at twelve and left at one o'clock.

Time.	Parts of Carbonic Acid in 10,000.	
	Dec. 15, 1890.	Mar. 20, 1891.
11.30	4.95	3.89
12.15	13.97	6.07
12.25	15.27	8.44
12.35	13.76	11.29
12.45	12.03	11.37
12.55	11.73	10.56
1.05	6.32	6.62
1.40	4.19	3.72

in the investigation of the public water supplies of the State, has been carried on in the chemical and biological laboratories of the Institute under the charge of the professors of Chemistry and Biology. Marked improvements in the methods of chemical and biological examination of waters have been made in the course of this work. During the past five years, nearly ten thousand samples of water have been examined, and the study of the results has given conclusions of the highest value. The connection between the chemical and biological composition of natural waters, and their influence on health, are now better understood than ever before, and a great part of the previously existing literature on this subject has been superseded as the result of this investigation. The students of the Institute have the privilege of following this work, which is still in progress, in connection with their own study of water analysis.

DEPARTMENT OF SANITARY ENGINEERING.

All the students of Civil Engineering receive instruction in Sanitary Engineering, but there is also a distinct course in this subject, in which the work is differentiated from that of the regular civil-engineering course, by the substitution of chemical and biological study for some of the work in railroad and bridge engineering. The object sought, in this arrangement, is to give the student reasonable familiarity with the practice and with the literature of the chemist and the biologist, as related to problems of water supply and sewage disposal.

The student in the course in Sanitary Engineering has, in the first year, a very complete course of study and laboratory practice in general chemistry, followed, in succeeding years, by the elements of organic chemistry, analytical chemistry, water analysis, air analysis, the chemistry of

natural waters, and theories of water purification, and sewage disposal. Similarly, he pursues, in order, the study of general biology, biology of micro-organisms, bacteriology, and sanitary biology. These studies, also, are supplemented by practice in the laboratory, and the student is taught to observe and to identify the various animal and vegetable organisms present in natural waters and in sewage.

The more strictly engineering studies, bearing upon sanitary work, which are pursued, are those of the construction, heating, ventilation, and drainage of buildings; of the designing and construction of works for the collection, storage, purification, conveyance, and distribution of water; and of the arrangement and proportioning of systems of sewers and of works for sewage treatment and disposal.

Instruction in sanitary-engineering subjects is given variously by the aid of lectures, text-books, problems, and drawing-room exercises. Since this branch of engineering is, in large degree, concerned with applications of the principles of hydraulics, much time is devoted to that subject. The student is made familiar with the laws governing the pressure of water, and its flow through pipes, canals, and other conduits, and with the methods applicable to the measurement of the volume of flowing water, by orifices, weirs, nozzles, meters, etc. Careful measurements are made of the flow of some river by means both of current meters and of floats, and this work is supplemented by in-door practice in the hydraulic laboratory, where a variety of experiments are made upon the flow of water, and in tests of efficiency of pumps, turbines, and other motors. This laboratory is fitted with appliances, probably nowhere excelled, for the prosecution of either class work or individual research in hydraulics. In the drawing room the student is required to make a complete design for a system of sewers for a portion of a town, determining the align-

ment, grades, and sizes in detail; and, in so far as time will allow, various other problems, such as the designing of large sewers, dams, standpipes, and other structures, are worked out.

DEPARTMENT OF ARCHITECTURE.

In the department of architecture, there is taught, in the courses relating to hygiene, the practical methods of land drainage, in the various contingencies that may occur, to insure a healthy site for buildings. Plumbing is carefully considered in all its parts. The house system is first planned; the proper construction of lines of iron soil pipes is shown, in their joint connections; and the arrangement of air pipes to insure a constant circulation of fresh air throughout the system. The various schemes for the disposal of sewage, by cesspool, sewer, or subsoil irrigation, are discussed. The various types of traps, water-closets, bowls, bath tubs, sinks, etc., are compared, and, finally, the proper methods of connecting them with the soil pipes are explained, with the final tests to prove the tightness of all joints and connections.

The department has a very complete set of models to assist in showing the proper construction of the plumbing system. In the draughting room are given problems in design for school buildings, hospitals, theatres, etc., where the study of heating, ventilation, and plumbing is an important feature. In the final theses, the student is encouraged to choose a building in which one of these schemes shall be embodied in its full importance.

DEPARTMENT OF PHYSICS.

In this department the subjects which are more immediately related to the public health are Heating and Ventilation.

Instruction is given in these subjects to three classes,

students in Mechanical Engineering, Sanitary Engineering, and in Architecture. The study, as pursued by the students of these courses has much in common, though shaped for each course with reference to the general work, immediate and prospective, of the classes named. With the class made up largely of students from the department of Mechanical Engineering the aim is to give prominence to the mechanics of and mechanism for ventilation. With the Architects special attention is given to the construction and arrangement of buildings with reference to simplicity of methods for and economy and effectiveness in warming and ventilating work, and to the adaptation of different methods and appliances to the various types of structures, and of working conditions encountered in an architect's profession. The studies of the Sanitary Engineer emphasize the relations of air to life, the methods of warming, cooling, moistening, drying, cleansing, or otherwise treating the air; also the method of measuring air volumes used for ventilation purposes, and of making determinations relative to vitiation or purity, and the methods of applying data of such character to the analysis of ventilating problems.

Instruction is given chiefly by lectures. Two books are used, Dr. Billings's book on Heating and Ventilation, and lithographed notes prepared for the students. Problems are given the students for solution, and two of the sections, the Sanitary Engineers and the Architects, make inspection of buildings illustrating the various types and systems of heating and ventilation.

DEPARTMENT OF GEOLOGY.

The instruction in this department bears on sanitary conditions of living in the lectures on Climatology, and on the relation of water-bearing strata to the water supply of communities.

During the progress of the course on Climatology there are frequent discussions of the influence which the factors of climate have upon the health, comfort, dwellings, and development of mankind. The importance of the ranges of temperature, as well as the means; the suddenness and the violence of the changes; the influence of the winds, whether cold or hot, moist or dry; the occurrence of fogs and cloudiness; the relation of the humidity of the atmosphere in distinction from the rainfall; and the effects of neighboring mountains, plains, deserts, sheets of water, and forests, are among the topics considered in their relations to the healthfulness of regions. Especial attention is given to the combined result of all the atmospheric phenomena of a region, and to the physical effects which the compound climate has upon the inhabitants.

The discussion of the occurrence of permeable and impervious layers of rock-materials shows how, by their association, water-bearing strata are formed in which there may be considerable hydrostatic pressure. It also treats of how the subterranean passage of waters is influenced by cracks and joints in the rock, by seams between the layers, and by the inclination and continuity of strata. It likewise explains how these and other geological conditions may and do affect the purity of waters derived from springs and wells, and shows the possibility of obtaining unwholesome waters at considerable distances from the sources of their contamination. It also explains how a system of drainage may be comparatively safe under one class of geological conditions, while in the presence of certain other structures of rock and sub-soils it may become the source of positive danger.

In addition to the above courses of instruction there is also an advanced course in Vital Statistics.

Following are the subjects of some of the theses of students of the graduating classes of the Institute, during the last five years, which relate to Hygiene and Biology : —

Design for a System of Sewerage for the City of Newton, Mass.

A Biological Study of the Charles River at Charles River Village, and at Newton Upper Falls, and of the Water Supply of Newton, Mass.

A Biological Study of the Water Supply of Waltham, Mass., and of the Charles River at Waltham and Watertown.

The Determination of Organic Matter in Air.

Projects for Improving the Drainage of the Low Districts in Boston.

A Design for a Quarantine Hospital.

A Design for a Sewerage System for the Town of Winchester, Mass.

A Discussion of the Methods used in Flushing Sewers.

Stand-pipes, their Construction and Arrangements.

Thermal Stimuli as a source of Reflex Action.

An Investigation of the Effect of Electricity on Micro-organisms.

Methods used in Ventilating Sewers.

The Purification of Water by Vegetable Organisms.

A Discussion of the Different Systems of Water Supply.

The Microscopical Analysis of Potable Waters by a new Quantitative Method.

A Design for the Plumbing System of a City House.

A Sanitary Bacteriological Study of the Milk Supply of Boston.

A Study of the Zoöglœa Stage of Bacteria.

Distribution of Nitrogen and Phosphorus in the Products of Modern Milling.

The Determination of Nitrogen in Well Waters.

The Action of Alumina on Ammonia in Natural Waters.

A Comparison of Various Sewer Cross Sections with Respect to Velocity and Discharge.

A Study of Methods for the Determination of Nitrates in Natural Waters.

The Action of Different Bacteria in the Decomposition of Casein and Milk Sugar.

Amœba Proteus; An Investigation of its Life-history and Physiology.

The Flow and Yield of Ground Water.

Some of the Species of Bacteria found in the Boston Water Supply.

A Design for a System of Water Supply for the Town of Walpole, Mass.

A Design for a Sewerage System for a Portion of the Town of Walpole, Mass.

The Life-history and Physiology of the Thread-leaved Sundew.

The Physiology of Digestion in the Starfish.

The Decomposition of Milk by Bacteria.

The Physiology of the Circulatory and Nervous Systems of the Earth-worm.

The Occurrence of the Eberth-Gaffky Bacillus in the Dejecta of Typhoid Patients.

The Disposal of Sewage on the Land at Framingham, Mass.

A Study of the Mystic Water Supply of Boston.

A Study of the Ventilation of Sever Hall of Harvard College.

Design for a System of Sewerage for a part of the Town of Wellesley, Mass.